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[54] METHOD AND DEVICE FOR PREPROCESSING STREAMS OF ENCODED DATA TO FACILITATE DECODING STREAMS BACK-TO BACK

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[52] U.S. Cl. 370/389

[58] Field of Search 370/389, 493, 370/496, 498, 535, 536, 537, 538, 539, 540, 541, 542, 543, 474, 476, 477; 348/461, 462, 466, 467, 390, 395, 396, 394, 404, 409, 12, 13, 19, 607, 391, 400, 412, 384

[56] References Cited

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[57] ABSTRACT

A method and device for preprocessing streams of encoded data (e.g. compressed in accordance with an MPEG standard) to permit a decoder to decode the streams, back-to-back (i.e., one stream immediately following another), without being reset and without producing video artifacts. The present invention includes verifying that a multiplexed stream complies with an encoding standard and preprocessing packets of the packetized encoded video sequence such that no video artifacts are produced when a video decoder decodes an adjacent encoded video sequence.

17 Claims, 16 Drawing Sheets

Docket no. 21^4

EXHIBIT B

FIG. 1
(PRIOR ART)

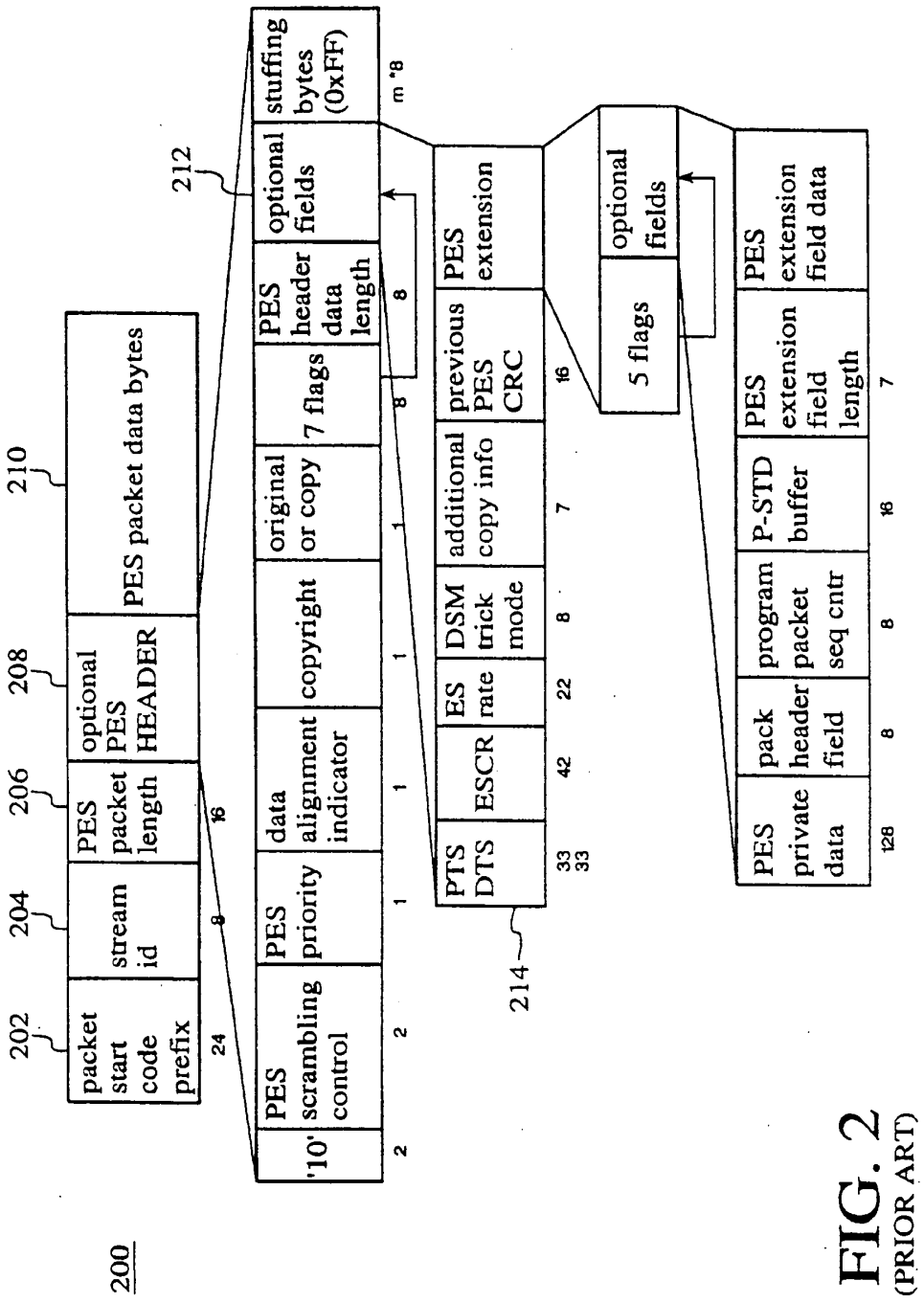
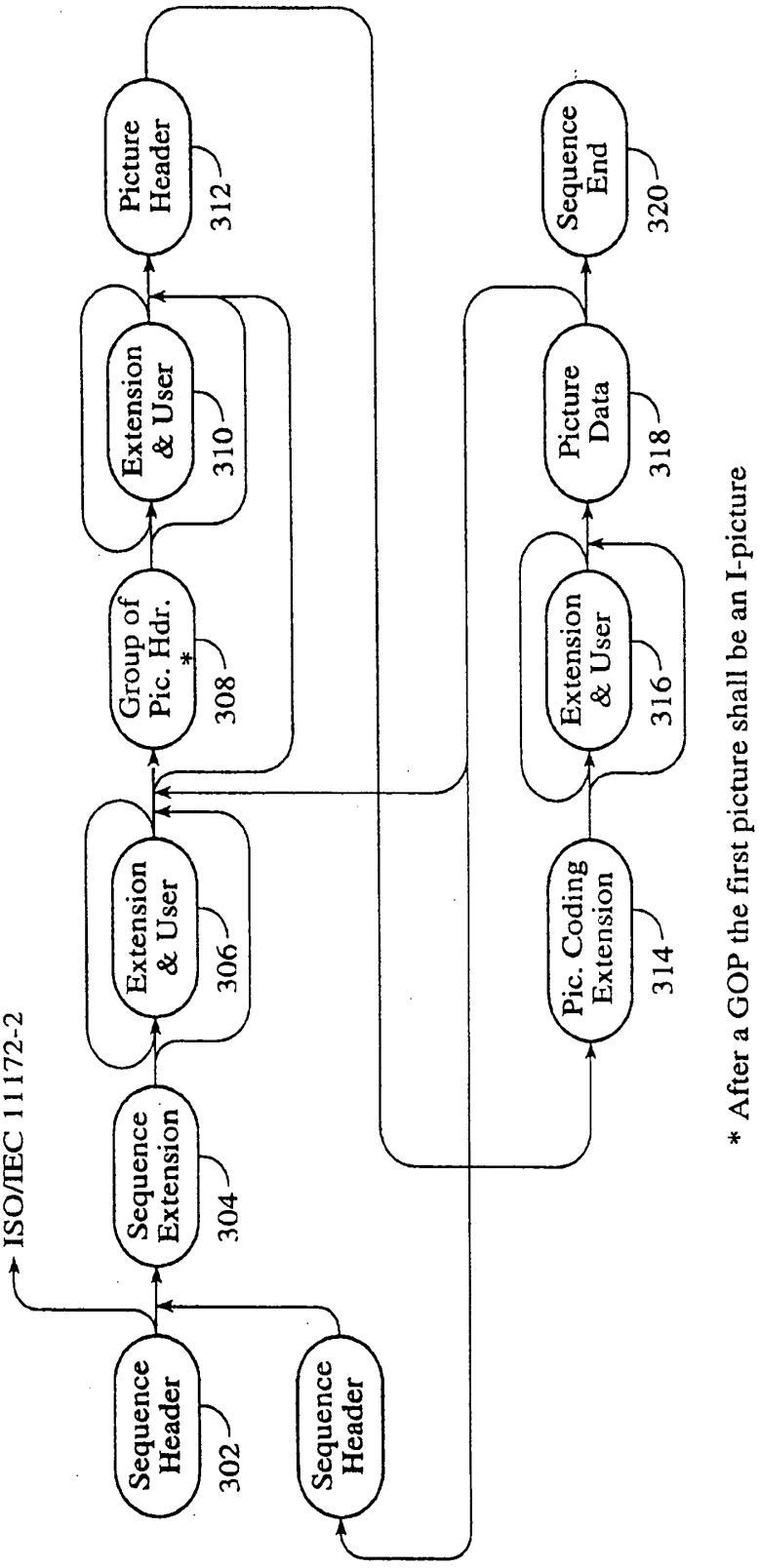


FIG. 2
(PRIOR ART)



* After a GOP the first picture shall be an I-picture

FIG. 3A
(PRIOR ART)

video_sequence0 {	300	No. of bits	Mnemonic
next_start_code0			
sequence_header0	302		
if (nextbits0 = extension_start_code) {			
sequence_extension0	304		
do {			
extension_and_user_data(0)	306		
do {			
if (nextbits0 = group_start_code) {			
308 group_of_pictures_header0			
310 extension_and_user_data(1)			
}			
312 picture_header0			
314 picture_coding_extension0			
316 extensions_and_user_data(2)			
318 picture_data0			
} while ((nextbits0=picture_start_code) ||			
(nextbits0 = group_start_code))			
if (nextbits0! = sequence_end_code) {			
sequence_header0			
sequence_extension0			
}			
} while(nextbits0!=sequence_end_code)			
} else {			
/*ISO/IEC 11172-2 */			
}			
sequence_end_code	320	32	bslbf
}			

FIG. 3B
(PRIOR ART)

FIG. 4
(PRIOR ART)

picture_header0 { 312	No. of bits	Mnemonic
picture_start_code 502	32	bslbf
temporal_reference 504	10	uimsbf
picture_coding_type	3	uimsbf
vbv_delay	16	uimsbf
if(picture_coding_type = 2 || picture_coding_type = 3) {		
full_pel_forward_vector	1	
forward_f_code	3	uimsbf
}		
if (picture_coding_type = 3) (		
full_pel_backward_vector	1	
backward_f_code	3	uimsbf
}		
while (nextbits0 = '1') {		
extra_bit_picture /* with the value '1' */	1	uimsbf
extra_information_picture	8	
}		
extra_bit_picture /* with the value '0' */	1	uimsbf
next_start_code0		
}		

FIG. 5 (PRIOR ART)

group_of_pictures_header0 { 308	No. of bits	Mnemonic
group_start_code ~ 604	32	bslbf
time_code	25	bslbf
closed_gop ~ 602	1	uimsbf
broken_link	1	uimsbf
next_start_code0		
}		

FIG. 6 (PRIOR ART)

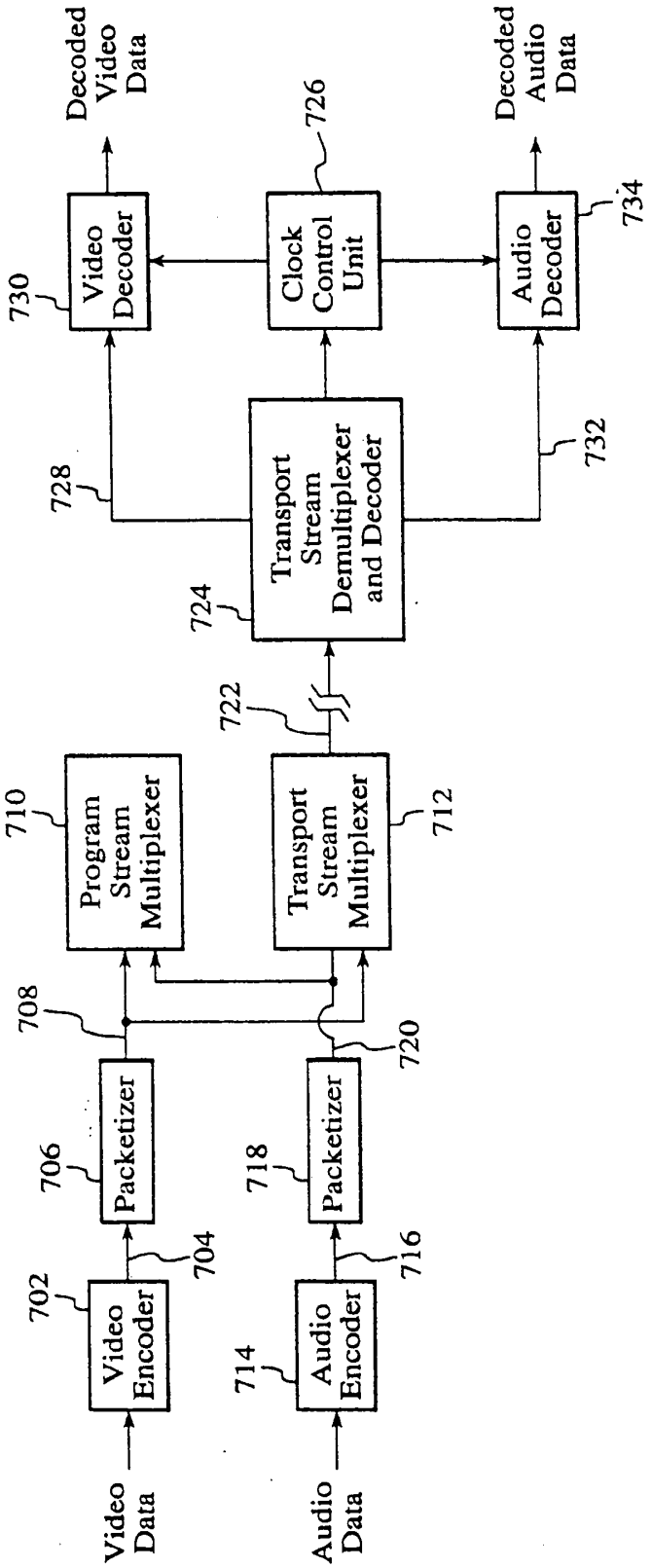


FIG. 7
(PRIOR ART)

FIG. 8

FIG. 9

FIG. 10

FIG. 11
(PRIOR ART)

FIG. 12

FIG. 13

FIG. 14

FIG. 15

FIG. 16

METHOD AND DEVICE FOR PREPROCESSING STREAMS OF ENCODED DATA TO FACILITATE DECODING STREAMS BACK-TO BACK

BACKGROUND OF THE INVENTION

a. Field of the Invention

b. Related Art

The MPEG standard focuses on the encoding and transport of video and audio data. In general, the MPEG standard uses compression algorithms such that video and audio data may be more efficiently stored and communicated.

The International Organization for Standardization (or the Organization International De Normalisation) (hereinafter referred to as "the ISO/IEC") has produced the MPEG II standard for the coding of moving pictures and associated audio. This standard is set forth in four documents. The document ISO/IEC 13818-1 (systems) specifies the system coding of the specification. It defines a multiplexed structure for combining audio and video data and means of representing the timing information needed to replay synchronized sequences of the audio and video data in real-time. The document ISO/IEC 13818-2 (video) specifies the coded representation of video data and the decoding process required to reconstruct pictures. The document ISO/IEC 13818-3 (audio) specifies the coded representation of audio data and the decoding process required to reconstruct the audio data. Lastly, the document ISO/IEC 13818-4 (conformance) specifies procedures for determining the characteristics of coded bitstreams and for testing compliance with the requirements set forth in the ISO/IEC documents 13818-1, 13818-2, and 13818-3. These four documents, hereinafter referred to, collectively, as "the MPEG II standard" or simply "the MPEG standard", are incorporated herein by reference.

A bit stream, multiplexed in accordance with the MPEG standard, is either a "transport stream" or a "program stream". Both program and transport streams are constructed from "packetized elementary stream" (or PES) packets and packets containing other necessary information. A "packetized elementary stream" (or PES) packet is a data structure used to carry "elementary stream data". An "elementary stream" is a generic term for one of (a) coded video, (b) coded audio, or (c) other coded bit streams carried in a sequence of PES packets with one and only stream ID.

FIG. 2 is a diagram which illustrates the syntax of a PES packet **200**..

The payload **210** of a PES packet **200** may carry a sequence of video frames or audio frames, for example. FIGS. 3*a* and 3*b* illustrate the high level organization of a video bitstream (or video sequence) **300** in accordance with the MPEG II standard. As shown in FIGS. 3*a* and 3*b*, the video bitstream (or video sequence) **300** includes a sequence header **302**, which may be followed by a sequence extension field **304**. The sequence extension field **304** may be followed by an extension and user field **306**, which may be followed by a group of picture header **308**, and optionally, another extension and user field **310**. In any event, a picture header **312** follows the sequence extension field **304** (in addition to any of the other fields). A picture coding extension field **314** follows the picture header field **312**. An optional extension and user field **316** follows. Next, the picture data **318** is provided. More sequences may be provided. Otherwise, the video sequence **300** is ended with a sequence end code **320**. Each section of the video sequence **300** is described in the MPEG II standard. However, for the reader's convenience, the sections particularly relevant to the present invention are described below

As shown in FIG. 4, the sequence header **302** includes a 32 bit sequence header code field **402** and an eighteen (18) bit rate value field **404**. The sequence header code field **402** is 000001B3 hex and identifies the beginning of a sequence header. The bit rate value field **404** identifies the bit rate of the video bitstream measured in units of 400 bits/second. A twelve (12) bit rate extension field may be included in the extension and user field **310**. Repeating the sequence header in the video bitstream allows data elements of the initial sequence header to be repeated to permit random access into the video sequence.

As shown in FIG. **5**, the picture header **312** includes a 32 bit picture start code field **502**, as well as a ten (10) bit temporal reference field **504**. The temporal reference field **504** is a unsigned integer associated with each input picture. This integer is incremented by one, modulo **1024**, for each input frame. If a frame is coded as two interleaved fields, the temporal reference **504** in the picture header **312** of both fields is the same. Following a group start code **604** in the group of pictures header **308**, the temporal reference field **504** is reset to zero.

FIG. **7** is a high level block schematic showing a system for encoding, communicating, and decoding video and audio data in accordance with the MPEG II standard.

The transport stream multiplexer **712** multiplexes the encoded audio and video packets to form a transport stream **100** and provides the transport stream **100** to communications link **722**. At a remote end of the communications link **722**, a transport stream demultiplexer **724** receives the multiplexed transport stream **100**.

Based on the packet identification (or PID) number **114** of a particular packet, the transport stream demultiplexer **724** separates the encoded audio and video packets and provides the video packets to a video decoder **730** via link **728** and the audio packets to an audio decoder **734** via link **732**. The transport stream demultiplexer **724** also provides timing information to a clock control unit **726**. The clock control unit **726** provides timing inputs to the both the video decoder **730** and the audio decoder **734** based on the timing information provided by the transport stream demultiplexer **724**. The video decoder **730** provides decoded video data which corresponds to the video data originally provided to the video encoder **702**. Similarly, the audio decoder **734** provides decoded audio data which corresponds to the audio data originally provided to the audio encoder **714**.

As mentioned above, transport streams **100** permit one or more programs with one or more independent time bases to be combined into a single stream. That is, a transport stream **100** may include a first program and a second program. In presently contemplated systems, both the video decoder **730**

and the audio decoder **734** must be reset before decoding a next program, for reasons which will be explained below. Thus, for example, in such systems there must be a temporal gap (e.g., one second) between the decoding of the first and second programs to permit the video and audio decoders **730** and **734**, respectively, to be reset. This temporal gap precludes the playing of the second program directly following the first program. Moreover, it is difficult to determine when one program ends and another begins in real-time. Thus, a method and/or a device is needed to permit more than one program to be played (i.e., decoded) back-to-back. The method and/or device should also overcome, or avoid, the difficulties of determining program boundaries in real-time.

Thus, as can be appreciated from the above discussion of MPEG and MPEG II video encoding, the video decoder **730** often needs past and future frames to decode a picture (B-Picture) frame. If the last temporal (displayed) frame of a first program is used in decoding a first temporal (displayed) frame of a second program, or if a partial video frame is used, the output of the video decoder **730** will have been improperly decoded, disadvantageously causing video artifacts. Thus, as discussed above, the decoders must be reset between programs in known systems.

SUMMARY OF THE INVENTION

Specifically, the present invention provides a method for preprocessing multiplexed streams of packets of packetized, encoded, audio and video sequences such that an audio decoder can decode the encoded audio sequence to produce an audio sequence and a video decoder can, without being reset, decode the encoded video sequence to produce a video sequence. The method of the present invention (i) verifies that the multiplexed stream complies with an encoding standard, (ii) preprocesses packets of the packetized, encoded, video sequence such that no video artifacts are produced when the video decoder decodes an adjacent encoded video sequence, and (iii) preprocesses the packets of the packetized, encoded, audio data sequence such that its start time is within a first predetermined time of the start time of the video sequence and its temporal length is within a second predetermined time of the temporal length of the video sequence.

The step of preprocessing the packets of the packetized, encoded, video sequence preferably includes (i) deleting any video frames that cannot be decoded if video frames of the video sequence are not temporally correct, and (ii) deleting any video frames following a code indicating an end of the encoded video sequence. The step of preprocessing the packets of the packetized, encoded, audio sequence preferably includes (i) removing any partial audio frames, (ii) adjusting (i.e., adding or deleting) the number of audio frames, if necessary, such that the audio and video sequences start within the first predetermined time, and (iii) adjusting (i.e., adding or deleting) the number of audio frames, if necessary, such that the temporal lengths of the audio and video sequences are within the second predetermined time.

FIG. 6 illustrates the structure of a group of pictures header of the MPEG II video sequence of FIGS. 3*a* and 3*b*.

FIG. 7 illustrates an encoding, transmission, and decoding system envisioned by MPEG II.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 2 is a diagram which illustrates the syntax of an MPEG II PES packet.

FIGS. 3*a* and 3*b* illustrate the organization of an MPEG II video sequence.

FIG. 4 illustrates the structure of a sequence header of the MPEG II video sequence of FIGS. 3*a* and 3*b*.

FIG. 5 illustrates the structure of a picture header of the MPEG II video sequence of FIGS. 3*a* and 3*b*.

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